The Geological Society of America
Special Paper 520
2016

Hydrophilanthropy gone wrong—How well-meaning scientists, engineers, and the general public can make the worldwide water and sanitation situation worse

David K. Kreamer*
Department of Geoscience, University of Nevada–Las Vegas,
4505 Maryland Parkway, Las Vegas, Nevada 89154-4010, USA

ABSTRACT

Efforts to improve water quality and quantity, and sanitation in the world are impeded by a variety of technical and socioeconomic issues often unfamiliar to well-motivated individuals. Sustainable technological improvement can be thwarted by the lack of consideration of regional norms, customs, mores, and traditions, and by the absence of feasibility assessment and coordination with the community both before and during instatement of local improvements. Specifically, the absence of coordination means not fully allowing users to define their needs, resources, issues, and maintainable solutions, and not understanding local and regional power dynamics and the ability of the community to provide long-term project stewardship. Other mistakes can include: a lack of long-term planning; inadequate scientific and engineering design and construction; lack of anticipation of contingencies and complicating issues and lack of adaptive management to deal with these unforeseen events; use of inappropriate technology; absence of educational efforts (both for the community to understand and provide stewardship for the project, and for the education of those installing the facilities in the community); lack of follow-up; and lack of technical expertise and leadership. There is no single approach to water and sanitation development that fits all situations. However, avoiding common pitfalls can bring these important resources to villages worldwide, and in the process empower communities, reduce sickness and mortality, and improve the human condition.

*dave.kreamer@unlv.edu

Kreamer, D.K., 2016, Hydrophilanthropy gone wrong—How well-meaning scientists, engineers, and the general public can make the worldwide water and sanitation situation worse, *in* Wessel, G.R., and Greenberg, J.K., eds., Geoscience for the Public Good and Global Development: Toward a Sustainable Future: Geological Society of America Special Paper 520, p. 205–219, doi:10.1130/2016.2520(19).

INTRODUCTION

The field of hydrology is not formally defined as an ethically endowed science, yet it naturally and directly lends itself to making the world better by improving water supply and water quality for both people and ecosystems, and by diminishing global sanitation problems. Many hydrologists therefore have the opportunity, if not the inclination, for philanthropic acts and activities. However, the implementation of positive water and sanitation and hygiene (WASH) projects in the economically developing world on a local level is fraught with obstacles, often brought on by the wide-ranging situational contexts of each project. No matter how well intended, projects to improve clean water and sanitation can fail and leave a community in worse shape than before the undertaking began. Project failure can waste resources and effort, but understanding common mistakes in WASH activities allows practitioners to avoid those pitfalls. The key to success in water and sanitation schemes lies in a deep understanding of the scientific and social setting in any chosen locale, implementation of appropriate technology, and proper developmental activities that promote the conditions necessary for a community to fully develop sustainable resources.

Hydrophilanthropy broadly reflects the altruistic efforts to provide sustainable, clean water for people and ecosystems worldwide. The definition encompasses many efforts, including: supplying reliable sources of water; improving sanitation; advancing health and mitigating water-related diseases; initiating and sustaining educational efforts in water and pollution; donation of money, infrastructural resources, expertise, and time for WASH efforts; and building capacity by teaching the public and creating new water scientists and engineers in regions with few resources. The approach, preparation, implementation, and follow-up for these projects can make the crucial difference between sustainable success and setbacks or even calamity that reverberates into the future.

CLEAN WATER AND SANITATION CHALLENGE

The scope of the problems preventing universal access to clean, reliable water supplies and sanitation is daunting. While water availability and quality statistics and development and health-impact projections from different organizations vary, the general consensus for the global situation is based on the World Health Organization and United Nations Children's Fund (United Nations, 2010; WHO, 2014), which estimate that 748 million people do not have access to clean drinking water. Broad, global estimates like this lack the insight and resolution that affect water development project work. For example, many estimates may not consistently define the distance to a water source beyond which water is not considered accessible, nor may they have a standardized definition of the quality threshold point where a water source is no longer classified as clean. The number of deaths attributed to lack of clean drinking water is also not exactly defined, but estimates are in the vicinity of 3.4 million people per year, many of whom are children (2.2 million per year; Sauer 2010). Mortality is difficult to estimate, as water shortages can have farther-reaching and cascading effects that produce other causes of death, such as drought-related malnutrition caused by livestock death and agricultural shortages from lack of rain and/or irrigation water.

In addition, there are broad socioeconomic consequences of clean water shortages and scarcity around the globe. This insufficiency of such a fundamental human requirement exacts a cost, both on regional economic development, and on a very personal level. The industrial production losses related to water-related illnesses of workers, health-related expenditures, and absenteeism is a detriment to many emerging economies. Some of the poorest regions are hardest hit. A United Nations report (UN, 2006) states that sub-Saharan Africa is estimated to have lost ~5% of gross domestic product in 2003 (or about US$28.4 billion) to water-related disease, which amounts to more than the total debt relief and aid to the region that year. Many children, particularly young girls, shoulder the burden of retrieving water from distant locations for domestic use, perpetuating gender-based inequalities in educational opportunities. Figure 1 shows photographs of young girls in northern Ghana pumping water and carrying heavy loads of water from community wells to their homes. According to the United Nations (2006), water-related illnesses have overall accounted for the loss of ~443 million school days each year. Prolonged drought and climate variability can instigate human migration and displacement, fostering major societal upheaval. In one example, the sub-Sahelian drought of 1968–1975 killed ~250,000 people outright, but the long-term effects were also profound. Millions of herd animals died, and resultant malnourishment and associated brain development injuries affected a generation of children, devastated the economy of eight countries in the region for decades, and displaced large populations (Abbott, 2004).

Statistics suggest that lack of sanitation is even more pervasive. The World Bank (2014) estimates that 2.5 billion people do not have access to improved sanitation, and 1 billion practice open defecation. Many emerging human settlements, consisting of unimproved housing and lacking supporting infrastructure, occur along streams and rivers, where human waste is directly discharged and runs off. It is estimated that, of the ~60 million people added to the world's urban populations and villages each year, most move to informal settlements (i.e., slums) with no sanitation facilities (UN, 2008). These unofficial settlements form near cities, in part due to rapid urban development, and can result in microbiological contamination and eutrophication of freshwater bodies (Palaniappan et al., 2010). Some researchers calculate that more than 80% of sewage in economically emerging nations is sent to receiving waters as raw, untreated wastewater (UN, 2009). Urban growth and crowding can also affect groundwater, where pit privies are located close to water-supply boreholes (Zingoni et al., 2005; DWAF, 1997; Kreamer and Usher, 2010; Chidavaenzi et al., 2000; Xu and Usher, 2006).

Figure 1. Young girls pump and carry heavy loads of water in northern Ghana. Some dwellings can be several kilometers distant from active wellheads.

The human community is not the only recipient of the negative consequences of clean water scarcity. Drought and climate variability can affect water-reliant ecological communities, and compounding this problem, many small but important ecological communities are vulnerable to nearby water exploitation and industrial activity. For example, springs can host a groundwater-dependent ecosystem that may serve a key role in the biodiversity and evolution of extensive regions (e.g., the Andean Paramó), but their roles can be highly dependent on water quantity and quality fluctuations (Buytaert et al., 2006). Springs can provide indispensable habitat for many endangered species, and they support untold hundreds of rare or unique species of plants, macroinvertebrates, fish, amphibians, reptiles, and mammals. In arid portions of the United States and Australia, for example, numerous spring-endemic fish populations exist, including the families of Cyprinidae, Cyprinodontidae, Goodeidae, Poeciliidae, Gobiidae, and other families (Liu et al., 2003; Hershler and Liu, 2008; Murphy et al., 2012). In both arid and mesic lands, springs can play disproportionately large roles in adjacent upland ecosystems. The scope of the worldwide clean water challenge extends far beyond a single species, and hydrophilanthropic efforts aimed at improving and protecting natural systems can help sustain bio-networks dependent on water.

Truly, clean water is a precious resource. About half of the human population is affected by water problems, as are a large number of ecosystems (Kreamer, 2012). These stresses have the potential to exacerbate local or regional conflict and struggles for economic and social advancement (Pacific Institute, 2012; Kreamer, 2012). Conflicts can erupt between users, the so-called "race to the pumphouse" (Burke and Moench, 2000), with individuals and user factions attempting to secure for themselves as much of the benefit of the extractive value of the water as possible. The distinction between water's private or public ownership fuels these conflicts, and often there is little social consensus. These stresses can also make food supply less secure, negatively influence efforts for energy development, reduce local equity among people, reduce progress toward poverty alleviation, and harmfully impact wildlife and its habitat (UN, 2009; Burke and Moench, 2000). Hydrophilanthropic WASH efforts should follow a considered scientific and social approach to address these human and ecological vulnerabilities, be interactive with affected local communities, and, optimally, be designed for long-term sustainability.

DISENCHANTMENT WITH TRADITIONAL PHILANTHROPIC WASH EFFORTS

There are tens of thousands of groups that try to conduct humanitarian assistance for water and sanitation. Associations that seek to alleviate suffering from water and sanitary privation include secular and faith-based nongovernmental organizations (NGOs). NGOs exist in all countries—some of the better funded are from North America, Europe, and Australia, but all are important. These NGOs include multilateral and bilateral agencies, and volunteer groups, and they embody the direct action of individuals.

Many charitable groups in the water and sanitation sector, regretfully, do not have a good record of long-term transformative success. Breslin (2010, p. 65) pointed out that perhaps the standard measure of positive results (i.e., the number of beneficiaries) should be replaced with the goal of sustainability:

> Despite the images that dominate the sector—pictures of children happily gulping water from a new tap or the counter-image of women collecting water from dirty puddles—the real image should be the one that plays itself out every day all over the world of the woman walking slowly past a broken handpump, bucket at her side or on her head, on her way to (or from) that scoop hole or dirty puddle that she once hoped would never again be part of her life.

Breslin outlined many surveys of water-supply and sanitary systems that point to philanthropic WASH inefficiency, and that exaggerate project coverage and functionality. For example, the Breslin report showed major reporting discrepancies in a pilot program in Sanga District of northern Mozambique, where the government reported that 72% of the villages had acceptable water supplies, but where data later confirmed the actual coverage was 21.91%, due in large part to a lack of initial recognition of the failure of individual water points (Breslin, 2003). The results of Malawi's appraisals of water point efficacy are distressing, with districts like Chikwawa and Phalombe reporting

less than 50% project functionality, while other districts were not much more efficient (Kampala, 2007; Breslin, 2010). These post-project assessment results highlight the need for increasing consideration of sustainability in development projects (McConville and Mihelcic, 2007).

Many other water system failures have been reported. A survey of 21 African nations (Harvey and Narkevic, 2009) reported that 36% of installed well pumps were nonfunctional. The Institute for Environment and Development (IIED, 2009) reported that in the Menaca region of Mali, 80% of water points are "dysfunctional," and 58% are in need of repair in northern Ghana. The University of North Carolina at Chapel Hill reported that, out of 898 boreholes constructed over a 20 yr period by the Christian hydrophilanthropic group World Vision, 20% were not functional, which is actually a comparatively good record (Reuters, 2014). Schweitzer (2013, p. 3) cites the Hague, Netherlands, International Water and Sanitation Centre's 2009 "slippage" roundtable briefing notes concerning wells,

> In the last 20 years, 600,000–800,000 hand pumps have been installed in sub-Saharan Africa, of which some 30 percent are known to fail prematurely, representing a total failed investment of between $1.2 and $1.5 billion.

A 2014 study in rural Madagascar of water systems that had been rehabilitated in the past 5 yr revealed that just under half of the 186 systems visited by researchers had broken down in the last year, with one third of those (~16.6% of the total systems per year) not fixed properly. In that same study, only half were listed as working in the preceding year, 10% didn't work at all, the average water system functionality was 9 mo/yr, and ~25% of the areas in rural Madagascar had no reliable water supply (Ryan, 2014). The selected water system failures listed here, and many others listed by groups such as Improve International (2014a), point toward the need for more reliability and sustainability in hydrophilanthropic efforts.

Data on sewerage show similar system inefficiencies and reporting problems (Improve International, 2014b). For example, in the recovery from war and continuing conflict, Iraq's major cities have been slow to repair water and sanitary infrastructure that has been damaged or destroyed. A 2008 report (Economist, 2008) observed that no more than 13% of all sewered sanitation in India is actually treated, and in Bihar, India, an estimated 90% of the population will revert to open defecation when the local pit is full (Improve International, 2014b). One survey in Madagascar concluded that for the study's assessment period, only 25% of all villages were open defecation free (ODF), or a 75% failure rate (Ryan, 2014; Improve International, 2014b). Improve International also referenced another study, commissioned by Plan International in Ethiopia, Kenya, Sierra Leone, and Uganda, which found that after initial appraisals and sanitation classification of close to 5000 households from 116 villages, 92% had to be reassessed for noncompliance with ODF verification criteria (FH Designs, 2013). In other failures, Shan (2012) reported that the highly touted dry "eco-toilets" installed in China's Daxing community in Inner Mongolia were quietly replaced after years of putrid odors, medical difficulties, and maggots, while in another study, the Water and Sanitation Program found that Cambodian latrine usage promoted by community-led sanitation schemes was only 15% effective (WSP, 2012).

Often, WASH projects in the economically developing world are conducted without sound geoscience expertise in siting wells and other facilities. Misplaced boreholes can results in dry or near-dry wells, or contamination from nearby human and animal waste disposal, and can diminish or eradicate nearby and/or down-gradient traditional water sources such as springs. These WASH failures in water system reporting and implementation illustrate that not all is well in the philanthropic water and sanitation arena, but they also emphasize the need for better, more considered efforts.

WHAT CAN GO WRONG IN WASH EFFORTS, DESPITE THE BEST INTENTIONS

The data in the previous section reveal that many good efforts to bring water to communities have not been sustainable. There are numerous ways a WASH effort can go wrong by those wanting to install water and sanitation facilities. These errors by practitioners include: (1) the lack of understanding of local customs, beliefs, values, mores, and traditions; (2) absence of coordination with the community before and during installation of WASH facilities; (3) no long-term planning for sustainability; (4) inadequate scientific and engineering design and construction; (5) lack of anticipation of contingencies and complicating factors; (6) inappropriate technology for the community; (7) no educational efforts, both for the community to understand and provide stewardship for the project, and for the education of the those installing WASH facilities in the community; (8) lack of follow-up; and (9) lack of technical expertise and effective leadership. Some of these errors can be addressed by establishing an understanding and trust between WASH practitioners and communities. This typically means taking the time to establish: communication, appreciation of the local customs and history, mutual respect, genuine friendships, and an ability to work together. Other aspects of success involve the ability to assemble the proper material and professional resources, to carry out and follow up on planning with public participation, and to create an authentic sense of project stewardship. Large, quantity-driven WASH undertakings sometimes are self-constrained by overly ambitious objectives, skipping over and missing fundamental community interactions necessary to sustained success.

Lack of Observance of Other Cultures, Mores, and Traditions

Specific plans for water and sanitary development can make scientific sense, but they potentially may contravene the local village political and/or social order. Not observing cultural norms in

dress and religious rituals, and not obtaining stakeholder "buy-in" can directly lead to the ultimate failure of a WASH project. To avoid this, it is crucial to fit into a local community situation, which in turn hinges on proper feasibility, preparation, and scoping for a project, particularly including community discussions and development of cultural understanding before the potential project begins.

Local cultural customs and religious practices can include, but are not restricted to: modest dress; not working at certain times of day, on specific days of the week, or during particular times of the year and holidays; and respect for sacred places. Further, lack of coordination with local communities and a dearth of appreciation of local insights, knowledge, and abilities before a WASH project can lead to underutilization of resources, counting on resources that are not available, and at worst, a patronizing attitude on the part of project workers toward the indigenous population (B. Usher, personal commun., 2 November 2014). The latter attitude is sometimes unrecognized by those engaged in WASH efforts. Breslin (2010, p. 68) pulled no punches on this last point, emphasizing the importance of local community project stewardship, stating:

> This story plays out day after day in Africa despite the compelling stories told by the NGOs and service organizations who demand more money to help the poor. The underlying message of free water systems is that communities are "too poor," "too disorganized," or (dare we say what all this truly means) "too incompetent" to actually lead their own development. The undertones are patronizing without exception. The reality is that most NGOs and almost all hands-on practitioners do not have the time, patience, or the real access and understanding of community development to establish the sound financial underpinnings critical to project success.

Economic development failures abound where local circumstances and practices are not adequately considered by planners. For example, the Norwegian government donated US$22 million for a fish-processing plant on Lake Turkana in northwestern Kenya that ended up with very poor results. Conceived and planned in 1971, the goal of the undertaking was to provide jobs by stimulating fishing and fish export. The people of the Turkana region were highly nomadic and had no history of catching or consuming fish, and the completed plant operated for only a few weeks before it closed. Other problems associated with the plant included the lack of availability of large quantities of the necessary clean water to run the plant, and the high cost to run freezers integral to the plant's operation and efficacy (NBC News, 2014).

In another example, the French government spent over $300 million from 1932 to 1982, with the Office du Niger, to grow cotton and rice and provide hydropower to desert areas of Mali. This forced more than 30,000 workers to relocate to the northeast. Despite this large investment and disruption, Malian laborers generally disregarded attempts to change their long-established farming traditions. By the end of this 50 yr period, just 6% of the region was developed, and the small amount of agricultural infrastructure that had been established was falling apart. In 1985, the World Bank took over the project, resulting in some limited success with local rice production (NBC News, 2014). Other problems have followed in Mali, with the Millennium Challenge Corporation (2012) signing a $460 million irrigation agreement with the Malian government in 2006 to develop irrigated agriculture. The project was ended early when a military coup ousted the elected government in 2012, and the initial plan of irrigation of 14,000 ha was scaled back to 5200 ha. The Malian government also has attempted large-scale land lease agreements to attract foreign investment in farming and irrigation, but the practice has been criticized as lacking transparency and violating the resources rights of established communities. The development of these foreign-led irrigation efforts has led to competition for existing water and forced resettlement of local population in the absence of published social or environmental impact studies (Baxter and Mousseau, 2011; Brondeau, 2011; Bunting, 2010). These projects required considerable water planning and significant outlays of money, yet they lacked critical community coordination, feasibility studies, and appreciation of cultural and socioeconomic local conditions, which eventually resulted in project failure and wasted resources. The lessons of these water-related project failures are all related to the imposition of an outside "solution" to local problems, without the necessary input of local people.

These last examples are huge projects, but many of the lessons learned can be applied to smaller WASH projects as well. On both large and small scales, there are many faith-based organizations that consider, in addition to WASH activities, their primary mission to be conversion of others to their beliefs. Forcing preordained WASH schemes and outside values on recipient communities, without proper communication, runs a terrible risk of wasted resources, loss of social capital, misunderstanding, and the generation of ill will.

Lack of Community Participation and Assessment before and during WASH Operations

A perfectly constructed well, put in a village in need of water, but also put in the wrong tract of land, can start a local water war and create hard feelings that can last generations. Therefore, preparation before and communication throughout a water or sanitation project are vital. Dissimilar organizations handle this basic groundwork for WASH projects differently with varying success.

Rotary International is an example of an organization that attempts to build community "buy in" into their philanthropic efforts. Projects are suggested by potential recipient communities, and Rotary Clubs from that community come up with partial resources toward the completion of the project. The projects are vetted, listed on their Rotary Global Grants Web site (http://www.matchinggrants.org/global/), and then contributing/matching funding and resources come from other Rotary Clubs around the globe. Rotary also has an "action group," with an acronym "WASRAG" (Water and Sanitation Rotary Action Group, http://www.wasrag.org/index.aspx). In the WASRAG, the realities of implementing an effective project are recognized as taking 3 to 5 years to be

sustainable, and that local community engagement and appropriate technologies are keys to success. This organization has acknowledged that solutions need to consider complex realities such as geography, geology, climate, and local culture. They also recognize that ensuring a project based on best practices isn't easy, requiring skills often not readily available (WASRAG, 2014).

While Rotary International is not 100% effective in its WASH efforts, it makes concerted efforts to identify and respond to the communities' self-defined needs and realizes that many projects require a long-term commitment.

Another organization that takes sustainability (and financial transparency) seriously is Water for People. In 2013, this group provided $14,751,190 for worldwide initiatives, and this amount was augmented by $4,609,227 from local partners, governments, and communities—for a total investment of $19,360,417 toward terminating water and sanitation penury. One important philosophy espoused by this group involves shared project investment and moving from 100-percent outside funding (that can release communities and from their accountability for long-term water supply financing) to mutual responsibility for sponsorship (WFP, 2015). Water for People is an organization that embodies the values of full financial transparency, and promotion of WASH project stewardship by local communities.

The groundwork of coordinating the planning and execution of hydrophilanthropic projects takes patience, communication, humility, and an open attitude toward cooperative problem-solving. Unfortunately, many water and sanitation professionals, confident in their credentials and experience, and eager to lend aid, either skip or do not adequately consider coordination with the community in planning and implementing a WASH project. The schedules of many well-intentioned overseas volunteers, with prepurchased transportation and fixed dates for arrival and departure, lend themselves poorly to a more effective considered approach that can be thorough and adjust for unforeseen project events. With these accelerated time constraints, work can be rushed, corners might be cut, or the projects could be left uncompleted (Breslin, 2010). Also, specific and important details of local circumstance related to project success are learned through community involvement. This can include simple things that can be otherwise overlooked, such as discovering nonoptimal schedules for activities (e.g., well drilling or dam building during rainy seasons, conducting a project during religious or cultural holidays, seeking local workers during competing harvest activities, and planning/scheduling the transport of equipment in locales where transport is very slow or impossible). Skipping the important step of coordination with the community, before and during a WASH operation, can make a successful outcome highly unlikely (Prüss-Üstün et al., 2008).

No Long-Term Planning for Sustainability

Many WASH projects do not adequately design their efforts to address prolonged maintenance, necessary refurbishment, and renewal. There is, however, no single approach for creating a sustainable WASH project. Each situation requires tailoring a methodology that utilizes the best of the local community and of WASH advocates and is built to address a range of future contingencies. Some innovative ideas and far-reaching guiding principles and stratagems have been developed in the past few years. These principles address an unfortunate aspect of volunteer "hands-on" work and investment from outside, in the respect that these hydrophilanthropic efforts do not automatically engage the local community, and, perhaps of equal importance, in the words of one author, outside volunteerism often "displaces the local private sector, undermining a key role player that the community will eventually need" (Breslin, 2010, p. 72). By linking WASH project construction and long-term maintenance to local jobs creation and local partnerships, hydrophilanthropists can increase the odds of lasting success.

Several authors have discussed WASH sustainability in an organized way and suggested methodologies to enhance project development and protracted project maintenance. McConville and Mihelcic (2007), for example, delineated a "sustainability audit" methodology that facilitates the organization and prioritization of project elements to promote sustainability. They list causal factors that influence project sustainability, including sociocultural respect and community participation, both discussed already herein. They also list political cohesion, economic sustainability, and environmental sustainability as important causal attributes. These authors encouraged an adaptive management approach, predicated on community participation throughout the project life cycle. They proposed interactive methodologies for five life phases of a development project, which they defined as: "(1) needs assessment, (2) conceptual designs and feasibility, (3) design and action planning, (4) implementation, and (5) operation and maintenance" (McConville and Mihelcic, 2007, p. 937). There are many variations of these ideas that have been adopted elsewhere.

One approach to engage the community in long-term planning for partnership and sustainability is referred to as a "livelihoods-based" approach, that is, an approach that provides for community employment. A test case of this methodology for WASH programs was put together for the fast-growing settlement of "C-Section," Duncan Village, in East London (Buffalo City Municipality), in the Eastern Cape of South Africa (A. Lucas, personal commun., 8 August 2005). Duncan Village is a low-income community (75.5% with no regular income) of ~80,000–100,000 people in post-apartheid South Africa, with minimal infrastructure facilities, high population densities (as much as 2500 people/hectare), and half of the main city's population crowded into 2% of the village land area (UNESCO, 2014). Reported figures have listed ~3500–6000 formal dwellings and 14,000–15,000 shacks, and estimates have shown as many as 200 families utilizing only one toilet and a large amount of multiple-occupancy housing (UNESCO, 2014; Sam and Wiseman, 2006). The residents of the informal dwellings of C-Section, adjacent to Duncan, are particularly impoverished and without electricity. The area also has an unsettled history of violence, the most

devastating being the Duncan Village Massacre in 1985, when extreme fighting erupted after the murder and funeral of United Democratic Front leader Victoria Mxenge. Historically, the area led much anti-apartheid activity in the 1980s, and in the turbulence after Mxenge's funeral, 19 people died and 138 were injured (South African Press Association, 1996). Duncan Village has suffered from past institutional neglect, but in recent years, it has put together a participatory planning process to address and deal with a variety of community problems, including the lack of clean water supply and sanitation. In addition to addressing WASH concerns, the stakeholder-based program of reconstruction and development stressed refuse removal, primary health, adult education, job training, contractor development, and child health care clinics (UNESCO, 2014; A. Lucas, personal commun., 8 August 2005).

One of the things that sets this Duncan Village "livelihoods" test case apart, in addition to creating more livable conditions in the village, is the concerted effort to facilitate formation of locally based businesses. This was carried out by creating and promoting local skills, while at the same time ensuring the delivery of resource targets at a competitive cost and with comparable quality to services that otherwise would be brought in from the outside. The fundamental program goals included: (1) participation of the community, (2) the creation of job opportunities without gender bias, (3) teaching of technical skills to unskilled and semiskilled personnel, (4) the transference of administrative commercial and managerial skills (and therefore project control) to community members, (5) retention of development expenditures within the local village as much as possible, and (6) fostering of local contractors/entrepreneurs to join and be part of the formal business community (UNESCO, 2014).

The WASH program for Duncan Village C-Section began with municipal meetings to introduce the overall strategy and project goals, and election of a community project steering committee. First steps also included establishment of a memorandum of understanding between all parties, and, importantly, community workshops to identify issues. Unhealthy water quality in the area had created a polluted environment, particularly in the stream drainages where human waste was directly dumped from "slow buckets" (containers used in the home as toilet facilities and then carried and discarded later). This unhygienic practice had the potential to spread disease; cause eutrophication and loss of river life; and generate nuisance conditions of odors, flies, and mosquitoes; and because of associated frequent sickness, it reinforced local unemployment and poverty.

Through structured facilitation, the community identified the underlying root causes of pollution, created a flow chart–type "problem tree," and pinpointed specific interventions aimed at the root causes. Under "water quality effects," for example, in the decision tree, there were four identified subcategories of: sewer blockages and spilling, blocked toilets, rubbish in the community, and sullage and storm water. Each of these subcategories were further subdivided. Under "sewer blockages and spilling," for instance, the root causes identified by the community included sewer pipes being too small, water leaks, putting foreign matter into manholes, and illegal connections. The first-step interventions for these root causes were also pinpointed and were: obtain an engineer's evaluation of piping shortcomings, and initialize community awareness campaigns to move toward better community practices. Initial seed funding was supplied by South Africa's Department of Water Affairs and Forestry (DWAF) and the Danish Development Assistance Program (DANIDA, 2014).

A feature intimately tied into the decision-tree problem solving in C-Section was the creation of new community service jobs and local entrepreneurial enterprises, which aimed at reversing past failures. In one past Duncan Village failure, well-meaning agencies had installed toilet facilities, despite the absence of local accessibility to toilet paper and any community awareness campaigns as to how these toilets were to be used and maintained. The toilets quickly became blocked and overflowed to the surroundings, creating a worse health hazard than before the toilets were installed. Solutions to this problem were community education sessions to explain how toilet plumbing works, and plans to start a local toilet paper factory (A. Lucas, personal commun., 8 August 2005). The livelihoods-based approach exhibited in this project is a way to promote sustainability of WASH efforts.

Other groups handle long-term planning in different ways. In some cases, upscaling can be accomplished from small demonstration projects to widespread implementation (Burke and Moench, 2000). Another more institutional approach is followed by the NGO Water for People, which builds sustainability into its basic philosophy of operation with what is called a "3, 6, 10" plan (Breslin, 2010, p. 70). These numbers stand for specific sustainability criteria. The "3" stands for the goal that 3 yr after project completion, there is "evidence that money is available for repairs, that repairs are happening… and the account is well managed (accurate financial management, no fraud, etc.)" (Breslin, 2010, p. 70). The 6 stands for the goal that 6 yr after project completion, sufficient funds are on hand to replace the most costly component of the system. The "10" stands for the goal that 10 yr after the water point completion, "adequate money is available to replace the entire water system" (Breslin, 2010).

This "3, 6, 10" plan defines and links "core sustainability indicators" to "financial indicators." Core sustainability indicators for water supply are defined as: (1) water meets acceptable quality criteria of the host country over time, (2) sufficient water quantity is available for households to meet host country standards in the long term, (3) the water system is inoperable no more than one day a month, and (4) the number of users at any given water point does not exceed host country standards (Breslin, 2010). The "3, 6, 10" link with financial indicators holds the Water for People group accountable for work done.

The best outcome for financial sustainability, perhaps, would be a community's ability to have internal funding mechanisms in place to make repairs without external support. Many factors can affect long-term financial sustainability of WASH projects, such as the community's willingness to pay for resources; project size and complexity; life, durability, and availability of

parts; availability and compensation of supporting workforce; distribution of project returns; and specific financing and banking arrangements. Other factors that can affect sustainability are societal and policy related, such as the existence of laws and policies that impact the use of natural resources, transboundary issues, the degree of social cooperation, the effectiveness of community leadership, written or oral rules that regulate water or sewage system operation and maintenance, protected and/or endangered wildlife species dependent on water, long-term water quality requirements, and the existence of any local corruption affecting operations or finance. The requirements for WASH project sustainability vary with each unique site and situation, and extended success entails addressing many local contingencies, which also can change with time.

Inadequate Scientific and Engineering Design/Construction

When designing a project for water and/or sanitary improvement, it is important to get things right from a scientific and technical design point of view. If technical details are not planned and executed correctly, these mistakes and oversights can literally make people sick, if not increase mortality in a community. Many of the people engaged in hydrophilanthropy, and even groups of people, are not qualified to design and construct proper WASH systems (Hove et al., 2013). Because there are tens of thousands of philanthropic groups conducting WASH projects with varying degrees of resources and professional oversight and/or experience, there is a potential for some projects to fail.

Students in WASH-related academic programs can flourish and professionally grow in WASH activities with proper mentorship and guidance. These students may not only gain first-hand experience key to their futures, but they also can have transformative experiences in appreciation of different cultures. Figure 2 shows students from the University of Nevada System of Higher Education actively engaged in installing a rainwater collection system in Guatemala. These students raise their own funds and work with faculty mentors and associates in the economically developing world.

Conversely, unguided and unmentored students can be a risk to WASH success. Breslin (2010, p. 72) pointed out,

> Students getting degrees in engineering for instance would never be allowed to implement a project in the United States, for good reason. It is not clear why they are allowed to implement in developing countries.

However, fundamental mistakes have even been made by experienced, competent professionals as well.

There are some fairly common errors. For example, well design can have several pitfalls. An improperly grouted well can allow vertical movement of surface water down the borehole, water that often has commingled with fecal material from animals grazing near the wellhead. As shallow groundwater is increasingly exploited in rapidly growing urban areas, pit privies and other septic outfall systems often are located too close to water-supply boreholes, resulting in subsurface contaminant migration to these nearby wells. Figure 3 illustrates wells in close proximity to existing or planned pit privies near Lusaka in Zambia and near Mombasa in Kenya. If a well is placed up gradient from a spring, there is a potential to dry up that spring, and in the process destroy or diminish a groundwater-dependent ecosystem, and perhaps permanently interrupt a community water source. Such an endangered spring may not only provide water to a local community, but it might be tied up in local cultural, spiritual, or religious beliefs and practices. Occasionally, wells and other WASH structures are designed on boundaries between territories of rival communities, which can lay the groundwork for conflict. Some WASH structures are planned to utilize materials in construction that are not locally available, seriously escalating costs for project completion.

The chances of miscalculation can be reduced with multiple checks and external peer review on project details, involvement of the local community, and flexibility during the construction of WASH projects. There also is an abundance of helpful literature and guidance for many types of field projects. An example of such guidance for well installation, aimed at the less experienced, is *Water Supply Well Guidelines for Use in Developing Countries* (Schneider, 2014).

Lack of Anticipation of Complicating Factors and Contingency Planning

Not anticipating eventualities and future problems of WASH development can have consequences that range from unforeseen social detriment, on either a local or broad scale, to an enormous disaster resulting in the illness and death of many innocent individuals. A classic example is the case of arsenic in boreholes in Bangladesh and India. In 2006, a test case lawsuit was decided concerning the massive instance of arsenic poisoning in well waters in those countries. Several NGOs and attorneys brought a lawsuit against the British Geological Survey (BGS) and Britain's National Environment Research Council (NERC), on behalf of the lead claimant, Binod Sutradhar, for negligence in not testing for arsenic in Sutradhar's well in the Brahmanbaria District, east of Dhaka, Bangladesh in 1992, resulting in his poisoning. The BGS and NERC technical reports were based on the results of groundwater quality surveys that missed the presence of arsenic. These reports served as the basis for the drilling of thousands of wells. Some estimates project that these wells may have contributed to "one of the largest mass poisonings in history" (Brahic, 2004, p. 1).

In this test case, which had the potential to lead to thousands of additional lawsuits, it was argued that the agencies were negligent by not examining and discovering high arsenic in well water in Bangladesh and India, although they tested for other parameters (Clarke, 2001; Wire, 2006; Brahic, 2004; Hossain, 2006). After several appeals, the British House of Lords dismissed the case, upholding a lower appeals court ruling that Mr. Sutradhar

Figure 2. Students from the Student Association for International Water Issues, University of Nevada System of Higher Education, actively engaged in installing a rainwater collection system in Guatemala. Photo credit: Melanie Reed Krautstrunk.

had no reasonable prospect of establishing that a sufficient degree of proximity existed between himself and the NERC, that is, despite its failures, NERC was not directly responsible in a legal sense (Wire, 2006).

The human impacts of not accounting for high arsenic levels in Bangladeshi and Indian well waters have been huge. Thousands of contaminated tube wells for potable water supply were drilled in Bangladesh and India in the 1980s and 1990s, many by UNICEF and other philanthropic groups. Arsenic poses a risk to ~57 million people in Bangladesh (Hossain, 2006), and 100,000 are estimated to have been affected by high concentrations in shallow wells in the region (Brahic, 2004). Annually, another 270,000 have been estimated to have had cancer-related deaths, as long-term exposure to arsenic has been related to cancer of the kidneys, lungs, bladder, and skin (Brahic, 2004). In the words of Richard Wilson of Harvard University, "Bangladesh makes Chernobyl look like a Sunday-school picnic" (Clarke, 2001, p. 1). Clearly, the BGS, in their technical reports, did not anticipate complicating factors in their limited assessment of the large floodplain groundwaters of Bangladesh and India.

The debate rages on, although the lawsuit is over, as does the appearance of other challenges and other complexities that are hard to foresee. The BGS and NERC insist that there was no evidence at the time of their work to indicate the possibility of high arsenic in wells, while on the other hand, some experts have disagreed. Other places have experienced similar problems, for example, with lawsuits having been threatened in New Jersey, USA, when a coalition of environmental groups reported that perhaps as many as 700,000 New Jersey residents were drinking water high in concentrations of arsenic (Jacob, 2000). Many other potentially harmful water-quality parameters are being overlooked in many WASH projects. For a case in point, a scientifically studied impact of well hand pumps is that many have the ability to harbor pathogenic bacteria for long periods of time and can resist disinfection (Ferguson et al., 2011; Piyush et al., 2014). This could sicken users but is largely unrecognized as a potential problem. However, the inability to anticipate complicating scientific aspects of WASH projects is only part of the challenge.

Even on a small scale, community social interactions can doom a WASH project. A South African (who had installed

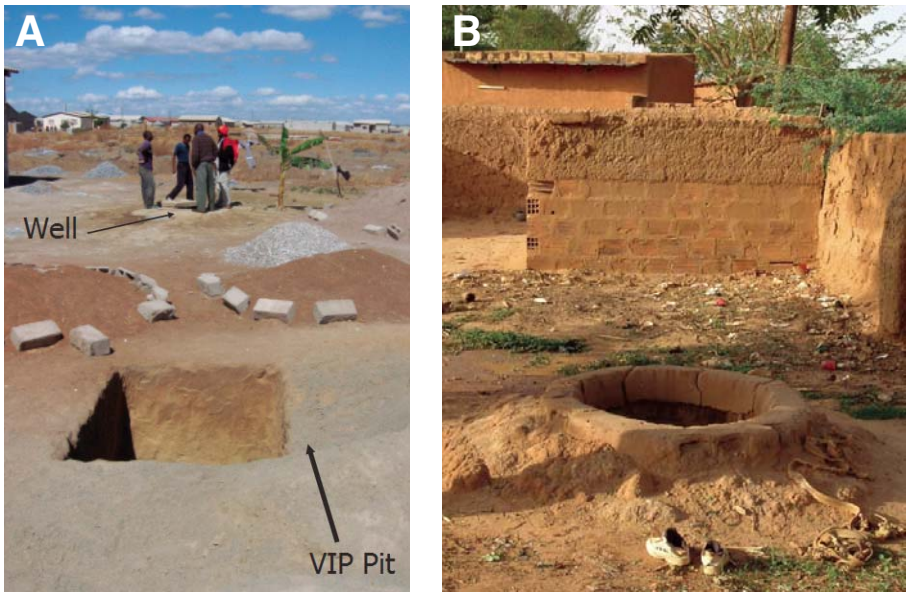

Figure 3. (A) Vulnerable well in close proximity to a planned ventilated improved pit (VIP) latrine near Lusaka in Zambia. (B) An exposed well ~2.5 m from an active pit privy (behind wall), near Mombasa in Kenya. Photo credits: Brent Usher.

hundreds of wells) related the account of a village whose newly installed borehole had its hand pump repeatedly ripped out, apparently by a chain attached to an automobile, in the weeks following its installation. Each time, the village elders insisted that the well was valued in the community, but the pump had "broken." The hand pump was reinstalled several times with the same result. It finally was learned that although the adults were in favor of this well, located conveniently in the center of the village, the young people in the community were not entirely like-minded. The children and younger people often had the responsibility to collect water for their families, and they were used to socializing out of the sight of adults at the old water gathering location down at the river. The new well would not afford them the privacy from their families they had previously enjoyed (M. Retief, personal commun., November 2014). It is clear that some social consequences of WASH projects are very difficult to anticipate.

Adaptive management practices (Holling, 1978) are a useful means of minimizing unintended, harmful consequences of WASH efforts. Optimally, these adaptive practices regularly reassess a project's evolving outcomes and are able to adjust to changing conditions with new methodologies, strategies, and perspectives. This iterative process can be a compelling approach to address uncertainties in the planning process. Some define adaptive management as a structured decision-making process. The U.S. Department of the Interior lists relevant activities in this process, including: "engaging the relevant stakeholders in the decision-making process, specifying objectives and trade-offs that capture the values of stakeholders, identifying the range of decision alternatives from which actions are to be selected, projecting the consequences of alternative actions, identifying key uncertainties, measuring risk tolerance for potential consequences of decisions, accounting for future impacts of present decisions, and accounting for legal guidelines and constraints" (DOI, 2015, p. 3).

Use of Inappropriate Technology

The economically developing world is full of stories of complicated, "state-of-the-art" WASH machinery breaking down, sitting idle, and perhaps being scavenged, sometimes within days of installation. Typically, this comes from the use of equipment and methods that are not optimal for a local populace. Often, the most appropriate technology is low technology. Manually driven pumps for wells can more easily be replaced and repaired than powered pumps. This quality can make them superior to motorized submersibles or electrical surface pumps, particularly in settings where only low flows of less than 2.25 m^3/h (~10 gpm) are needed.

One case that has been in the news illustrates the shortcomings of the roundabout "play pumps." The concept behind PlayPump International was to develop a water pumping system for wells that could be additionally used as a merry-go-round–type playground ride (PlayPump, 2014). The ride part of the pump is a disk that spins when pushed, providing centrifugal force to the riders, while at the same time providing energy to raise water to the ground surface up to a storage tank (usually made out of polyethelene). Play pumps are advantageous in particular community settings like large primary schools, where the present infrastructure is insufficient, and where there is plentiful high-quality, shallow groundwater (Stellar, 2010). Millions of charity donations have been poured into PlayPumps, but serious questions with the technology began to emerge recently (Chambers, 2009; Freshi, 2010).

The advertising for PlayPumps has been "top down, donor pleasing," but it has been ill-fitting in many of the target communities. Paul van Beers of FairWater.org (a water NGO) observed that PlayPumps have often been placed in rural environments with few children and that there were "millions of US dollars wasted." He goes on to say that, "Their marketing is perfect, but the final idea does not work" (Chambers, 2009**,** p. 1). Freshi (2010, p. 1) quoted an aid worker/engineer in Malawi as saying, "Each time I've visited a PlayPump, I've always found the same scene: a group of women and children struggling to spin it by hand so they can draw water."

Marketing claims for the program have been overblown, according to some critics. Chambers (2009, p. 1), for example, cited press releases and interviews proclaiming an ambition to build 4000 new PlayPumps in a year or two, to supply the "benefit of clean drinking water to up to 10 million people." However, the PlayPump is much less efficient in drawing water than traditional hand pumps or treadle pumps. Chambers (2009) cited information from the Sphere Project that calculated the following: In order to meet those ambitions and to supply a minimum 15 L per person each day, given the PlayPump's capabilities and efficiency, it would require children to be "playing" nonstop for 27 h each day at each pump. Another NGO, WaterAid, does not support PlayPumps for several reasons. These include: the high costs (four normal pumps could be installed for the price of one PlayPump), complicated pump mechanisms that are tough to operate and keep operational, the dependence on child labor, the community need for water at times when children would not be playing (during school hours, during inclement weather, and in the early morning), and the risk of injury (Chambers, 2009).

Choosing an appropriate WASH technology is a site-by-site, individual decision, and not a one-size-fits-all determination. Optimally, it should be carried out with a locally driven dialog and not an imposed ("top-down") methodology.

No Educational Efforts

Lack of educational effort handicaps a program's efficacy. WASH education is fundamentally a two-way flow of information. It is both for the community, to understand and provide stewardship for the project, and for those installing WASH facilities, to realize and appreciate the community context of their efforts (Prüss-Üstün et al., 2008). Robust educational WASH efforts involve all segments of the population, from academics and decision makers to villagers.

Formal public instruction at institutions of higher learning is a primary underpinning of WASH sustainability (Silliman et al., 2010). Sometimes called "capacity building" or "capacity development," technical education programs, workshops, short courses, and university instruction in the hydrologic or public health sciences all promote an expansion of regional competence and ability (Bethune and Ryan, 2010). Canadian programs such as the Red Centroamericana para la Gestion en Recursos Hidricos (or Central American Water Resource Management Network; CARA) network promote postgraduate degrees in the hydrologic sciences in Latin America (Bethune and Ryan, 2010), and Uniwater Education Limited (Uniwater, 2014), which aids water education programs in Africa, go a long way toward raising the standard of a region's capability and professionalism. Other academic groups such as the Universities Water and Sanitation Hygiene Network (UWASH Network; Laituri et al., 2010) in the United States promote dissemination of knowledge to other institutions, agencies, and communities, as do the many educational efforts by individual university faculty. Figure 4 shows visiting university professors and other professional experts giving lectures and short courses, which support information exchange and local competency. A well drilling field session in South Africa is pictured, as is a water-quality short course in Baghdad for the Iraqi Ministry of the Environment, and a water-related lecture is shown from Bindura University for Science Education in Zimbabwe. These are examples of activities supporting education and capacity building. If there is a drawback to some formal education, it is that certain efforts are haphazard and incomplete (often because of lack of adequate resources), and that in some situations, degreed professionals are produced in a locale with no jobs in that field, which often leads to that educated talent leaving the area, and not benefiting the home community.

Community education programs are geared toward the layperson and directly influence the continuity and sustainability of WASH stewardship. For example, Bartram and Cairncross (2010, p. 23) noted that in the case of sanitation and hygiene, the "exposure of everyone, particularly the carers of young children, to well-conceived hygiene promotion" by health professionals is a key task for improving the current situation. These programs can instruct the resident public on self-sufficient water-quality monitoring, well pump maintenance and repair, sanitary practices, health monitoring, and a host of other WASH-related competencies. One example of these programs is Notre Dame's University Partnership for Outreach, Research and Development in Uganda, which is one part of the diverse developmental activities undertaken by that university's Initiative for Global Development in sub-Saharan Africa. Beginning in 2008, with support from the Kellogg Institute for International Studies and the Ford Family Program in Human Development Studies, this partnership has allowed communities under stress and confronted with severe privation to change their circumstance, while at the same time providing educational opportunities for Notre Dame faculty and students. Some current, on-the-ground activities include: community beautification and gardening, expanding local medical expertise, and advancing clean water availability and hygiene (Notre Dame, 2015). In another example, Peace Corps projects have had varied success in addressing community education and sustainability in countries such as Panama. A postservice audit of water systems in 28 communities in that country revealed that once volunteers left, "significant variation" was seen in the state of the physical infrastructure and community capabilities. Some communities showed steady water service, while others had their water systems completely fall apart (Suzuki, 2010).

The education of WASH professionals and volunteers coming into a new community has the purpose of integrating these people, from outside the local society, into the practices, appreciations, customs, and knowledge base of the indigenous population (Campana, 2010). Education of hydrophilanthropic volunteers doing work in economically emerging nations can come in many forms. The Peace Corps program in the United States, started by President John F. Kennedy, accomplishes this in several ways. The program requires a 2–3 month training

Figure 4. (A) Well-drilling field training session near Kyalami, South Africa. (B) Water-quality short course in Baghdad, Iraq, for the Iraqi Ministry of the Environment. Use of water-quality multiprobes is being demonstrated. (C) Guest lecture on groundwater tracking, dating, and tracing is given for Bindura University for Science Education in Zimbabwe.

period before an individual can become a volunteer. This period includes a homestay where each volunteer lives with a local family, and where each is trained by the locals in language skills. The volunteer receives added training on cultural norms and acceptable behavior and is given mentors to "shadow" who are experienced volunteers (Szabo, 2014; Peace Corps, 2015). The Peace Corps also supports the Global Health Service Partnership (GHSP, 2014), which endeavors to boost training capacity for health professionals in the economically developing world and has an educational component called World Wise Schools that shares volunteer experiences in classrooms (WWS, 2014).

Education is a vehicle for preparing communities and groups of hydrophilanthropists for sustainable success, and for imbuing future generations with the knowledge and motivation to take up the WASH challenge.

Lack of Follow-Up

There are natural reasons as to why WASH endeavors often have no follow-up and commonly fail. The major constraints for individuals and small humanitarian groups who want to get involved in hydrophilanthropy are time and personal (or collective) resources. Typically, individuals and small charitable groups have limited free periods they can spend overseas. This is particularly true for those with regular jobs and students with school obligations. Many individuals have limited finances for repeated trips, as well as mistaken preconceptions of the time, methodologies, and finances necessary to be successful. This creates a tendency to have incomplete projects with no follow through. Burke and Moench (2000) wrote of groundwater management needs in a way analogous to WASH requirements, emphasizing that challenges persist even after successful remedial action and require continuing evolution and attention.

Many larger humanitarian groups have yet to switch their metric of success from the number of people served to superior measures of sustainability and permanency of WASH improvements. This lack of adoption of a long-term view lends itself to an absence of project follow-up. Efforts are further hampered by incomplete documentation and lack of data archiving, which inhibit the necessary continuity in WASH endeavors.

Lack of Experience and Leadership

Lastly, many WASH failures are directly attributable to inexperience of practitioners coupled with a commensurate absence of guidance and expertise. On the other hand, hydrophilanthropic efforts with leadership, mentoring, technical expertise, and continuing communication among practitioners and stakeholders typically have built-in resilience, underlying confidence, and the perspective provided by that experience. Many inexperienced but well-intentioned individuals embark on WASH efforts with a goal of improving conditions and reducing suffering in the world, but they have little practical knowledge of how this goal can be best realized in any given community.

LESSONS LEARNED—THE WAY FORWARD

Although the WASH landscape is fraught with obstacles, some basic approaches can make the path forward easier. Table 1 outlines potential pitfalls to WASH efforts discussed herein, root causes, and potential solutions to these obstacles.

From a practical point of view, if an individual is involved with a large hydrophilanthropic organization, he or she can check the group's commitment to high levels of communication with local communities, its preproject preparation, and its plan for postproject follow through. Many hydrophilanthropic groups have organizational Web sites that are easily accessible to individuals, with varying degrees of explanation of the group's motivation, goals, methodologies, philosophies, and ongoing and planned projects. Unfortunately, it is sometimes difficult for individuals searching these Web sites to find explanations of organizational philosophies and strategies. These core values of organizations can get lost in the Web site's marketing, requests for donations, and descriptions of the urgency of WASH problems. Additionally, even if the organizational practices and philosophies are well articulated, a single individual often does not have control over nonoptimal policies and practices of the organization with which they work. A viable approach in this circumstance may be to commit to operating WASH activities in a small target area over longer time periods. This will facilitate the establishment of long-standing relationships and local contacts, and the ability to adjust to any changing conditions. In addition to building trust and mutual respect, this approach can help WASH practitioners better understand limitations on resources, become familiar with local laws and policies, and identify potential opportunities. At the larger scale, leaders of large WASH groups can periodically review their respective organizations' metrics for determining success (e.g., numbers of people served vs. fewer but more sustainable projects). Optimal metrics for large philanthropic groups should include a demonstrable commitment to sustainability deeply imbedded in organizational values, a means for adaptive management, and periodic audits and review. Even a private individual working as part of a small charitable group has a great personal opportunity to establish standard procedures that can move a WASH project in a positive direction.

Sound, basic practices and philosophies improve the prospects for positive outcomes. By observing local customs, attire, and practices, outside workers can create good will. Conducting on-the-ground pre-evaluation and preparation, in conjunction with bringing adequate resources to bear, will lay the foundation for success. By imagining the long-term consequences of a WASH project, a group helps define possible snags and complications, and, when combined with some level of adaptive management, the organization can strategically adjust to uncertainties and change. Planning ahead for sustainability, specifically developing the local stewardship for the project, can help economic growth, create local jobs and businesses, and help raise a community out of poverty. Use of appropriate technology makes repairs easier. Following up on hydrophilanthropic ventures with postservice

TABLE 1. POTENTIAL CHALLENGES, PROBLEM CAUSES, AND SOLUTIONS TO HYDROPHILANTHROPIC EFFORTS AIMED AT IMPROVING WATER AVAILABILITY AND QUALITY, AND SANITATION AND HYGIENE (WASH)

Potential challenges to WASH activities	Possible root causes of problems	Potential solutions
Lack of observance of other cultures, mores, and traditions	• No understanding of local culture • Patronizing attitude by WASH workers • Poor communication with stakeholders • Not enough time living in the local community	• Research culture and traditions of community prior to arrival • Live in/frequently visit the community, prior to, during, and after the WASH activity • Communicate with locals and build understanding and trust
Lack of community participation and assessment before and during WASH operations	• Poor communication with stakeholders • Lack of organization of WASH participants • Political unrest	• Regular communication between WASH workers and community • Incorporation of community stewardship into all aspects of project • Financial transparency • Structured facilitation
No long-term planning for sustainability	• Paradigm of "number of people served" vs. "number of people served sustainably" • Expectation of lack of permanence	• Sustainability audit • Livelihoods-based approach • Upscaling from small pilot projects
Inadequate scientific and engineering design/construction	• Lack of technical expertise and mentoring • Lack of proper resources • Lack of care in WASH design	• Ensuring availability of technical expertise, guidance, and mentoring • Planning for having proper assets and contingent resources • Care in WASH design
Lack of anticipation of complicating factors and contingency planning	• Poor planning • Limit time/resources for project management and maintenance • Myopic view of WASH activities	• Working with community to plan for multiple outcomes • Incorporation of adaptive management practices
Use of inappropriate technology	• Lack of availability of proper construction resources • Lack of understanding of the potential for project vandalism • Lack of understanding of community's ability to repair broken facilities	• Better planning and assembling of assets before project • Understanding of local community resource and skill limitations
No educational efforts	• Missing technical expertise and mentoring • Need for community education facilitation • Limited time and resources for WASH participants	• Bring in additional outside educational resources • Commit to a household community education plan • Explore possible connections and collaborations with local schools and universities
Lack of follow-up	• Limited time and resources for volunteers • Incomplete documentation and data archiving	• Don't participate in projects where long-term sustainability, permanence, community participation and stewardship, and ensuring adequate resources are not priorities
Lack of experience and leadership	• Amateurs who don't know better • Limited resources, time, and expertise	• Planning and incorporating the participation of technical experts and facilitators

audits, evaluations of progress, and considered response allow any necessary corrections and optimization of a WASH project to proceed smoothly. This all hinges on good oversight and leadership, and a willingness to ask tough questions.

There is no single approach to water and sanitation development that fits all situations, but avoiding common pitfalls can bring these important resources to villages around the world, and in the process empower communities, reduce sickness and mortality, and improve the human condition.

ACKNOWLEDGMENTS

I would like to thank Greg Wessel, Jeff Greenberg, and the other referees and reviewers of this chapter for their thoughtful comments and suggestions. Their efforts have made this a better contribution, and their considerate and helpful reviews are greatly and gratefully appreciated.

REFERENCES CITED

Abbott, P.L., 2004, Natural Disasters (4th ed.): New York, McGraw-Hill, 460 p.

Bartram, J., and Cairncross, S., 2010, Hygiene, sanitation, and water: Forgotten foundations of health: PLoS Medicine, v. 7, no. 11, p. e1000367, doi:10.1371/journal.pmed.1000367.

Baxter, J., and Mousseau, F., 2011, Understanding Land Investment Deals in Africa: Mali, Oakland Institute, http://allafrica.com/download/resource/main/main/idatcs/00021029:0d0f31641207deae38bb314ff8a1bccd.pdf (accessed October 2014).

Bethune, D., and Ryan, C., 2010, The CARA Network: Building Latin American capacity in hydrogeology and water resource management: Journal of Contemporary Water Research & Education, v. 145, p. 45–50, doi:10.1111/j.1936-704X.2010.00081.x.

Brahic, C., 2004, Court Clears Geologists in Bangladesh Arsenic Case: SciDev.Net, http://www.scidev.net/global/pollution/news/court-clears-geologists-in-bangladesh-arsenic-case.html (accessed October 2014).

Breslin, E., 2003, Demand Response Approach in Practice: Why Sustainability Remains Elusive: District Mapping in Sanga, Niassa Province, Northern Mozambique: WaterAid, http://www.wateraid.org/documents/plugin_documents/elusivesustainability.pdf (accessed October 2014).

Breslin, E., 2010, Rethinking hydrophilanthropy: Journal of Contemporary Water Research & Education, v. 145, p. 65–73, doi:10.1111/j.1936-704X.2010.00084.x.

Brondeau, F., 2011, L'agrobusiness à l'assaut des terres irriguées de l'Office du Niger (Mali): Cahiers Agricultures, v. 20, no. 1–2, p. 136–142, doi:10.1684/agr.2011.0472 [in French].

Bunting, M., 2010, Mali: Whose land is it anyway? The Guardian, 28 December 2010, http://www.theguardian.com/world/2010/dec/29/mali-farmers (accessed November 2014).

Burke, J.J., and Moench, M.H., 2000, Groundwater and Society: Resources, Tensions, Opportunities: New York, United Nations Publication E.99.II.A.1, 170 p.

Buytaert, W., Célleri, R., De Bièvre, B., Cisneros, F., Wyseure, G., Deckers, J., and Hofstede, R., 2006, Human impact on the hydrology of the Andean páramos: Earth-Science Reviews, v. 79, no. 1–2, p. 53–72, doi:10.1016/j.earscirev.2006.06.002.

Campana, M.E., 2010, Hydrophilanthropy, WASH, and experiential learning in developing countries: Journal of Contemporary Water Research & Education, v. 145, p. 36–44, doi:10.1111/j.1936-704X.2010.00080.x.

Chambers, A., 2009, Africa's not-so-magic roundabout: The Guardian, 25 November 2009, http://www.theguardian.com/commentisfree/2009/nov/24/africa-charity-water-pumps-roundabouts (accessed November 2014).

Chidavaenzi, M., Bradley, M., Jere, M., and Nhandara, C., 2000, Pit latrine effluent infiltration into ground water: The Epworth case study, *in* Chorus, I., Ringelband, U., Schlag, G., and Schmoll, O., eds., Water, Sanitation and Health: London, IWA, p. 171–178.

Clarke, T., 2001, Bangladeshis to sue over arsenic poisoning: Nature, 11 October 2001, doi:10.1038/news011011-14, http://www.nature.com/news/2001/011011/full/news011011-14.html (accessed October 2014).

DANIDA, 2014, DANIDA: Udenrigsmisteriet [Ministry of Foreign Affairs of Denmark], http://um.dk/en/danida-en/ (accessed October 2014).

Department of the Interior (DOI), 2015, What is Adaptive Management?: U.S. Department of the Interior, http://www.doi.gov/ppa/upload/Chapter1.pdf (accessed June 2015).

Department of Water Affairs and Forestry (DWAF), 1997, A Protocol to Manage the Potential of Ground Water Contamination from On-Site Sanitation: Pretoria, South Africa, Department of Water Affairs and Forestry, Republic of South Africa, 43 p.

Economist, 2008, Creaking, groaning: Infrastructure is India's biggest handicap: Economist, v. 11, http://www.economist.com/node/12749787 (accessed October 2014).

Ferguson, A.S., Mailloux, B.J., Ahmed, K.M., van Geen, A., McKay, L.D., and Culligan, P.J., 2011, Hand-pumps as reservoirs for microbial contamination of well water: Journal of Water and Health, v. 9, p. 708–717, doi:10.2166/wh.2011.106.

FH Designs, 2013, ODF Sustainability Study (Paul Tyndale-Biscoe, Matthew Bond, Ross Kidd), December 2013, http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/Plan_International_ODF_Sustainability_Study.pdf (accessed November 2014).

Freschi, L., 2010, Some NGOs can adjust to failure: The PlayPumps Story: Aid Watch, Development Research Institute, New York University, February 19, 2010, http://aidwatchers.com/2010/02/some-ngos-can-adjust-to-failure-the-playpumps-story/ (accessed October 2014).

Global Health Service Partnership (GHSP), 2014, Global Health Service Partnership, Peace Corps: http://www.peacecorps.gov/volunteer/globalhealth/ (accessed October 2014).

Harvey, P., and Narkevic, J., 2009, Sustainable rural water supplies (SRWS) flagship: Work plan January 2009–December 2011, Publisher Rural Water Supply Network, RWSN, St. Gallen, Switzerland, 18 p.

Hershler, R., and Liu, H.P., 2008, Ancient vicariance and recent dispersal of springsnails (Hydrobiidae: Pyrgulopsis) in the Death Valley system, California-Nevada, *in* Reheis, M.C., Hershler, R., and Miller, D.M., eds., Late Cenozoic Drainage History of the Southwestern Great Basin and Lower Colorado River Region: Geologic and Biotic Perspectives: Geological Society of America Special Paper 439, p. 91–101, doi:10.1130/2008.2439(04).

Holling, C.S., ed., 1978, Adaptive Environmental Assessment and Management: London, UK, John Wiley and Sons, 377 p.

Hossain, M., 2006, Arsenic-poisoning lawsuit rejected by Britain, July 10, 2006: Mail and Guardian, http://mg.co.za/article/2006-07-10-arsenicpoisoning-lawsuit-rejected-by-britain (accessed October 2014).

Hove, M., Ngwerume, E., and Muchemwa, C., 2013, The urban crisis in sub-Saharan Africa: A threat to human security and sustainable development: Stability: International Journal of Security and Development, v. 2, doi:10.5334/sta.ap, http://www.stabilityjournal.org/articles/10.5334/sta.ap/ (accessed June 2015).

Improve International, 2014a, Statistics on Water Point Failures: https://improveinternational.wordpress.com/handy-resources/sad-stats/ (accessed October 2014).

Improve International, 2014b, Statistics on Sanitary Failures: https://improveinternational.wordpress.com/handy-resources/statistics-on-sanitation-failures/ (accessed November 2014).

International Institute for Environment and Development (IIED), 2009, Annual Report (2008/2009): International Institute for Environment and Development, http://www.iied.org/annual-report-2009 (accessed 24 October 2014).

Jacob, A., 2000, Lawsuits threatened over arsenic levels in New Jersey water: New York Times, 9 March 2000, http://www.nytimes.com/2000/03/09/nyregion/lawsuits-threatened-over-arsenic-levels-in-new-jersey-water.html (accessed November 2014).

Kampala, R.L.J., 2007, Waterpoints Mapping: WSSCC's Experience from Malawi: http://www.wsscc.org/fileadmin/files/pdf/publication/Malawi.pdf (accessed November 2014).

Kreamer, D.K., 2012, The past, present, and future of water conflict and international security: Journal of Contemporary Water Research & Education, v. 149, p. 87–95, doi:10.1111/j.1936-704X.2012.03130.x.

Kreamer, D.K., and Usher, B., 2010, Sub-Saharan African ground water protection—Building on international experience: Groundwater, v. 48, p. 257–268, doi:10.1111/j.1745-6584.2009.00570.x.

Laituri, M., Sternlieb, F., and Waskom, R., 2010, Call to action: Proposing a university network for water, sanitation, and hygiene: Journal of Contemporary Water Research & Education, v. 145, p. 74–80, doi:10.1111/j.1936-704X.2010.00085.x.

Liu, H.P., Hershler, R., and Clift, K., 2003, Mitochondrial DNA sequences reveal extensive cryptic diversity within a western American spring-snail: Molecular Ecology, v. 12, p. 2771–2782, doi:10.1046/j.1365-294X.2003.01949.x.

McConville, J.R., and Mihelcic, J.R., 2007, Adapting life-cycle thinking tools to evaluate project sustainability in international water and sanitation development work: Environmental Engineering Science, v. 24, no. 7, p. 937–948, doi:10.1089/ees.2006.0225.

Millennium Challenge Corporation, 2012, Mali Compact: Quarterly Status Report March 2012, Millennium Challenge Corporation, http://www.mcc.gov/pages/countries/overview/mali (accessed November 2014).

Murphy, N.P., Breed, M.F., Guzik, M.T., Cooper, S.J.B., and Austin, A.D., 2012, Trapped in desert springs: Phylogeography of Australian desert spring snails: Journal of Biogeography, v. 39, p. 1573–1582, doi:10.1111/j.1365-2699.2012.02725.x.

N.B.C. News, 2014, Examples of Failed Aid-Funded Projects in Africa: http://www.nbcnews.com/id/22380448/ns/world_news-africa/t/examples-failed-aid-funded-projects-africa (accessed November 2014).

Notre Dame, 2015, University Partnership for Outreach, Research and Development in Uganda: https://ndigd.nd.edu/notre-dame-projects/regions/sub-saharan-africa/#university-partnership-for-outreach-research-and-development-in-uganda (accessed June 2015).

Pacific Institute, 2012, Water Conflict Chronology: http://www.worldwater.org/conflict.html (accessed November 2014).

Palaniappan, M., Gleick, P.H., Allen, L., Cohen, M.J., Christian-Smith, J., and Smith, C., 2010, Clearing the Waters: A Focus on Water Quality Solutions: Nairobi, United Nations Environment Programme, UNON Publishing Services Section, 91 p.

Peace Corps, 2015, Peace Corps Volunteers: http://www.peacecorps.gov/volunteer/learn/ (accessed June 2015).

Piyush, G., Govind, P., Milind, G., Srivastava, D.K., and Misra, B.R., 2014, Study on the presence of faecal coliforms (*E. coli*) in groundwater samples of Gorakhpur City, India: International Research Journal of Environment Science, v. 3, p. 9–12.

PlayPump, 2014, Welcome to Roundabout Water Solutions: http://www.playpumps.co.za/ (accessed November 2014).

Prüss-Üstün, A., Bos, R., Gore, F., and Bartram, J., 2008, Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health: Geneva, Switzerland, World Health Organization, 53 p., http://apps.who.int/iris/bitstream/10665/43840/1/9789241596435_eng.pdf (accessed August 2015).

Reuters, 2014, The key to drilling wells with staying power in the developing world: Reuters, 2 September 2014, http://www.reuters.com/article/2014/09/02/worldvision-wells-idUSnPn831m42+80+PRN20140902 (accessed November 2014).

Ryan, P., 2014, Madagascar WASH Sector Sustainability Check: Peter Ryan, WASH Consulting, http://www.mineau.gov.mg/wp-content/uploads/filebasee/documentation/eauetassainissement/SC%20Final%20Report%20v1.pdf (accessed November 2014).

Sam, C., and Wiseman, A., 2006, Duncan Village redevelopment initiative: SCUPAD: http://www.scupad.org/web/userfiles/download/2006_sam_wiseman.pdf (accessed November 2014).

Sauer, J., 2010, Why US philanthropists should care about water and sanitation: The Huffington Post, 22 June 2010, http://www.huffingtonpost.com/john-sauer/why-us-philanthropists-sh_b_548221.html (accessed October 2014).

Schneider, S.J., 2014, Water Supply Well Guidelines for Use in Developing Countries (3rd edition): http://www.schneiderwater.com/pdf/Hydrophilanthropy_well_Guidelines.pdf (accessed August 2015).

Schweitzer, R.W., 2013, Community and Household Management Strategies for Water Supply and Treatment in Rural and Periurban Areas in the Developing World [Ph.D. dissertation]: University of South Florida, http://scholarcommons.usf.edu/etd/4765 (accessed online October 2014).

Shan, W., 2012, World's biggest eco-toilet scheme fails: ChinaDialogue, part of the Guardian Environment Network, 31 July 2012, http://www.theguardian.com/environment/2012/jul/30/eco-toilet (accessed October 2014).

Silliman, S., Mohtar, R.H., Paterson, K.G., and Ball, W.P., 2010, Engineering academic programs for hydrophilanthropy: Commonalities and challenges: Journal of Contemporary Water Research & Education, v. 145, p. 5–29, doi:10.1111/j.1936-704X.2010.00078.x.

South African Press Association, 1996, Truth Commission to Probe Duncan Village Massacre: http://www.justice.gov.za/trc/media%5C1996%5C9609/s960922a.htm (accessed November 2014).

Stellar, D., 2010, The PlayPump: What went wrong?, State of the Planet, Earth Institute, Columbia University, July 1, 2010, http://blogs.ei.columbia.edu/2010/07/01/the-playpump-what-went-wrong/ (accessed November 2014).

Suzuki, R., 2010, Post-Project Assessment and Follow-Up Support for Community Managed Rural Water Systems in Panama [Master's report]: Houghton, Michigan, Michigan Technological University, http://digitalcommons.mtu.edu/etds/515 (accessed August 2015).

Szabo, R., 2014, What to expect in Peace Corps pre-service training: Huff Post Impact, 11 November 2014, http://www.huffingtonpost.com/ross-szabo/peace-corps-preservice-training_b_857907.html (accessed October 2014).

United Nations (UN), 2006, United Nations Human Development Report 2006: New York, UN, p. 6–35.

United Nations (UN), 2008, Tackling a Global Crisis: International Year of Sanitation 2008: United Nations Water, http://esa.un.org/iys/docs/IYS_flagship_web_small.pdf (accessed October 2014).

United Nations (UN), 2009, The 3rd United Nations World Water Development Report: Water in a Changing World (WWDR-3)—Facing the Challenges: New York, United Nations World Water Assessment Programme 2009, http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/wwdr3-2009/downloads-wwdr3/ (accessed October 2014).

United Nations (UN), 2010, Targeting Resources for Better Results—The Challenge of Extending and Sustaining Services, United Nations Water Global Annual Assessment of Sanitation and Drinking-Water (GLAAS) 2010: Geneva, Switzerland, United Nations, 92 p., http://www.un.org/waterforlifedecade/pdf/glaas_report_2012_eng.pdf (accessed November 2014).

United Nations Educational, Scientific and Cultural Organization (UNESCO), 2014, Duncan Village: Provision of Sustainable Electrical Reticulation, South Africa, Best Practices for Human Settlements: UNESCO, MOST Clearing House, http://www.unesco.org/most/africa12.htm (accessed November 2014).

Uniwater, 2014, UniWater Education Limited, Training Africans to Solve African Water Problems: http://www.uniwatered.org/ (accessed November 2014).

Water and Sanitation Program (WSP), 2012, The Water and Sanitation Program, Sanitation Interventions in Cambodia—A Six-Country Study Conducted in Cambodia, China, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI), March 2012: http://www.wsp.org/sites/wsp.org/files/publications/WSP-ESI-assessment-Cambodia.pdf (accessed November 2014).

Water and Sanitation Rotary Action Group (WASRAG), 2014, Water and Sanitation Rotary Action Group: http://www.wasrag.org/index.aspx (accessed November 2014).

Water for People (WFP), 2015, Water for People: http://www.waterforpeople.org/about/ (accessed June 2015).

Wire, 2006, Proximity and Policy: The Bangladeshi Arsenic Cases, Sutradhar versus Natural Environment Research Council ("NERC") Ukhl 33: Wire, Product Liability and Injury, July 2006, http://www.scribd.com/doc/50359015/sutradhar (accessed October 2014).

World Bank, 2014, Sanitation: http://www.worldbank.org/en/topic/sanitation (accessed November 2014).

World Health Organization (WHO), 2014, Progress on Drinking Water and Sanitation—2014 Update: Geneva, Switzerland, World Health Organization, 78 p.

World Wide Schools (WWS), 2014, World Wide Schools: http://www.peacecorps.gov/wws/ (accessed October 2014).

Xu, Y., and Usher, B.H., eds., 2006, Groundwater Pollution in Africa: London, Taylor and Francis, 368 p., doi:10.1201/9780203963548.

Zingoni, E., Love, D., Magadza, C., Moyce, W., and Musiwa, K., 2005, Effects of a semi-formal urban settlement on groundwater quality, Epworth (Zimbabwe): Case study and groundwater quality zoning: Physics and Chemistry of the Earth, v. 30, no. 11–16, p. 680–688, doi:10.1016/j.pce.2005.08.008.

Manuscript Accepted by the Society 2 December 2015
Manuscript Published Online 7 March 2016

Printed in the USA